Tunable Magnetic States in Two-Dimensional Materials

Sudipta Dutta

Department of Physics, Indian Institute of Science Education and Research (IISER) Tirupati, Andhra Pradesh, India

Magnetism in reduced dimension has been of sustained interest due to diversity of quantum phases, originating from varying crystal symmetry and external perturbations. It has been extremely challenging since the long-range spin-ordering cannot sustain the thermal agitation due to vanishing spin-wave excitation gap, as described by Mermin-Wagner theory. Graphene has been a major breakthrough in the quest of two-dimensional (2D) materials. However, it does not show any signature of magnetism, unless introduced with structural defects or dopants. The ever-growing experimental sophistications have enabled the preparation and characterization of a plethora of 2D materials and further manipulation of their electronic structure to obtain desired functionalities.

The recent discovery of 2D ferromagnetic van der Walls crystals, mainly transition metal trichalcogenides and trihalides has added a new dimension in this quest. The presence of uniaxial magnetic anisotropy opens up a spin-wave excitation gap and therefore overcomes the thermal agitation to stabilize the long-range ferromagnetic order even in two-dimension, as observed in magneto-optical Kerr effect microscopy. This observed magnetic properties can further be tuned by various external perturbations, e.g., electric field, magnetic field, strain etc.

In this talk, I shall present the major breakthroughs in the field of 2D magnetism and related contributions from our group. I shall discuss about the defect and dopant induced magnetism in graphene, Fermi instability induced p-electron magnetism in blue phosphorene and the magnetoelastic responses in transition metal trichalcogenides. Our observations can be exploited for spintronic, memory-storage and qubit applications.

Reference:

1. K. Wakabayashi and S. Dutta, *Solid State Comm.* **152**, 1420 (2012).
2. S. R. Das and S. Dutta, "Edge state induced spintronic properties of graphene nanoribbons: A theoretical perspective", in *Carbon Nanomaterials Electronics: Devices and Applications*, Springer 2021, pp - 165.
3. S. Chabungbam, S. Mohakud and S. Dutta, *ACS Appl. Elec. Mater.* **2**, 3171 (2020).
4. S. Adhikary, S. Dutta and S. Mohakud, *Nanoscale Adv.* **3**, 2217 (2021).